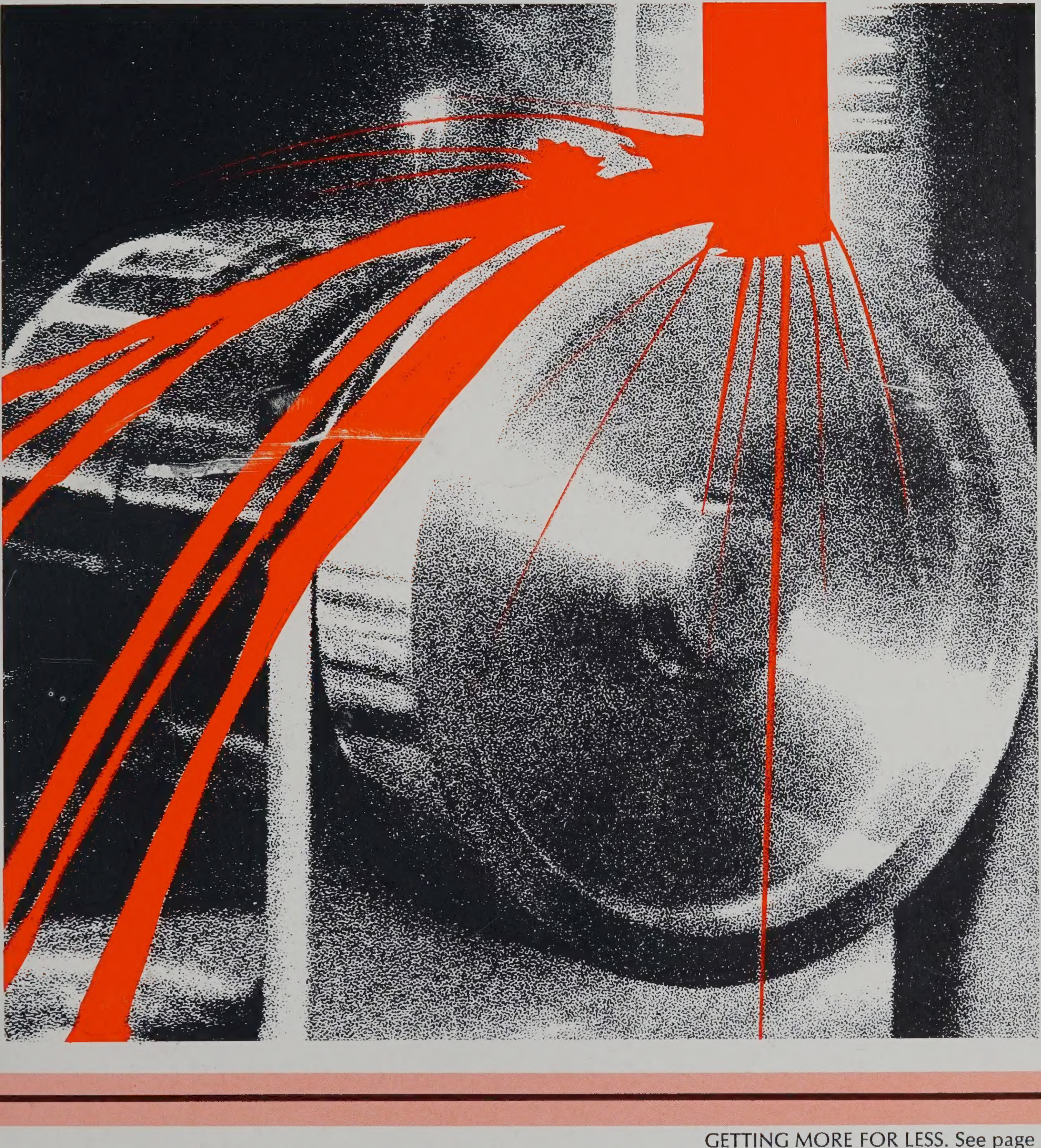
# DIMENSIONS NBS

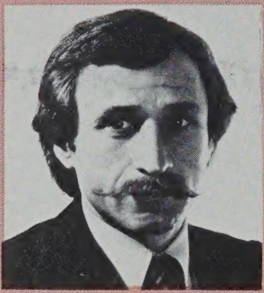
*The magazine of the*
*National Bureau*
*of Standards*
*U.S. Department*
*of Commerce*
*July 1981*



GETTING MORE FOR LESS. See page 2.

# COMMENT

## PRODUCTIVITY IN METALS PROCESSING



The future productivity of the materials industry, and especially the metals industry, depends in large measure on our response to a number of national problems that are now well recognized.

The high cost of energy, the uncertainty of market forces, the need for reduced and streamlined regulations, the increased competition from foreign manufacturers both in the United States and abroad, and the rapidly changing political posture of third world nations—together these forces present both pressures and opportunity to the field of metals processing. For it is through the development of improved metals processing techniques, new alloys, and more competitive metal products that we can boost lagging U.S. productivity across a broad spectrum of metals technologies that affect our national prosperity, security, and quality of life.

Rapid solidification processing, for example, promises to open a wide vista of new opportunities for manufacturers. With this technique, new alloys can be formed with novel microstructures and phases, while conventional alloys can be made with more refined and homogeneous structures. This makes possible a whole array of cost-effective products with improved properties. At the same time, rapid solidification can play an important role in the development of alloys that limit U.S. dependency on imports of cobalt, chromium, tantalum, and other critical elements.

While we have known for over a decade about the structural advantages produced by rapid solidification, the more recent "spotlight" on the technique followed the emergence of new commercial processes. These include centrifugal atomization for production of high temperature alloy powders, melt spinning for production of metallic glassy ribbons, and the use of directed high energy sources such as a laser or an electron beam for the modification of metallic surfaces.

The emergence of these commercial rapid solidification processes has provided renewed interest in the underlying science. As shown in the accompanying diagram, the field of materials science and engineering can be defined as a knowledge generation and transfer system that links the results of basic research with the needs and experiences of industry and society as a whole. Materials processing plays the central role in this system by determining the inner structures and properties of materials, hence the performance of finished products.

Up to now, the impetus for rapid solidification processing appears to have originated more from social pull rather than scientific push. We can be sure, however, in the long run, the true technological potential of rapid solidification will not be fully realized without the fundamental data base, and the incisive explanations offered by basic science.

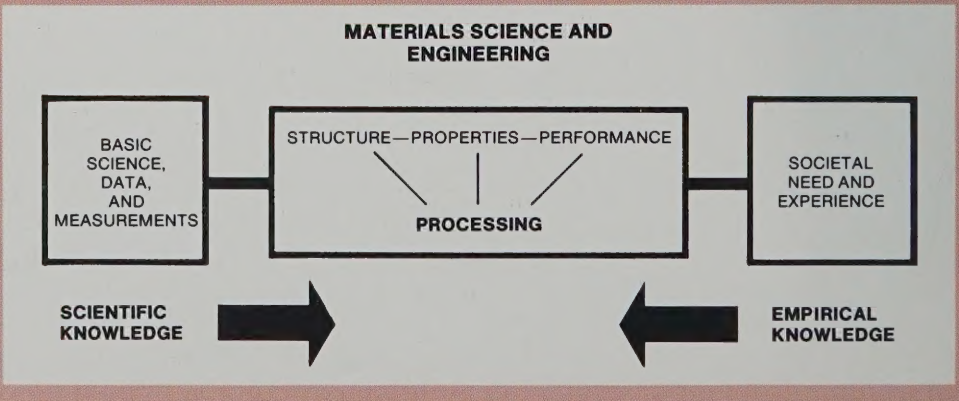
The NBS role in this crosscurrent of scientific and empirical knowledge is clearly defined on the left side of the diagram and includes the generation of basic scientific information, data, and measurement techniques that are relevant to societal needs. A better understanding of the fundamentals will permit development of predictive models explaining the complex interrelationships among rapid solidification processing variables—structure, properties, and performance.

Already, remarkable payoff is in sight from the work of Boettinger, Cahn, Coriell, Murray, Rosen, Schaefer, Shull, and others at NBS, as noted in the article on page 2 of this issue of DIMENSIONS//NBS. Also relevant to rapid solidification is a portion of our joint program with the American Society for Metals (ASM) on computer-generated phase diagrams. ASM is presently raising an additional $4 million from industry to combine with the NBS program. Advancement in the understanding and dissemination of phase diagrams is an essential step in the development of new alloys.

Direct interaction with and input from industry also plays an important part in shaping the Bureau's metallurgy program. In the past 3 years, for example, we have organized and cosponsored two conferences and a briefing/workshop on rapid solidification. The aim of these meetings was first, to review our current understanding of the fundamental principles and present applications in this field, and second, to set future directions for research and wider-range commercial exploitation of this technological breakthrough.

Robert Mehrabian

Robert Mehrabian, Chief
Metallurgy Division
National Bureau of Standards
B266 Materials Building
Washington, DC 20234
301/921-2811


MATERIALS SCIENCE AND ENGINEERING
BASIC SCIENCE, DATA, AND MEASUREMENTS
STRUCTURE—PROPERTIES—PERFORMANCE
PROCESSING
SOCIETAL NEED AND EXPERIENCE
SCIENTIFIC KNOWLEDGE
EMPIRICAL KNOWLEDGE

DIMENSIONS
NBS

*The magazine of the*
*National Bureau of Standards*
*U.S. Department of Commerce*
*Volume 65/Number 5*

*July 1981*

# Contents

## ARTICLES

**2** **Getting More for Less**
Improving Productivity in Metals Processing

**10** **Preserving the Past**
NBS Studies Film and Tape Deterioration

**12** **NBS Research Forges Strong Link with Industry**
Research Associate Program at NBS

## INTERFACE

**15** **ON LINE WITH INDUSTRY**
New NBS Instrument Monitors Electromagnetic Radiation

**16** **STANDARD STATUS**
Verification Procedures for Federal Interface Standards

**17** **STAFF REPORTS**
Hybrid Planar-Cylindrical Scanning Technique
Spin Dependent Mean Free Paths
New SRM Aids Detection of PAH's
Copper "Benchmark" SRM's Available

## UPDATE

**21** **CONFERENCES**
EMI Measurement Seminar
Durability of Building Materials and Components
Conference Calendar

**22** **PUBLICATIONS**
NBS Researcher Seeks Realistic Basis for Lighting Levels
Solar Collectors Designed for All Seasons
Seismic Standard Drafted for Federal Buildings
Publications Listing

**24** **NEWS BRIEFS**

COVER STORY

# GETTING MORE

## FOR LESS

# *Improving Productivity in Metals Processing*

*by Gail Porter*

THE alchemists of Europe's Middle Ages thought they were really on to something. A little of this, a little of that, and presto, "base" materials might be transformed into gold.

Modern metallurgists have no such grand illusions. Yet in aiming for more practical goals, they may be realizing much of the dream that eluded the alchemists. For prompted by the energy and minerals shortages of the 1970's, today's metallurgists are fast learning to get "more" from "less." With new techniques such as rapid solidification and with new alloy combinations and composites, they are creating materials with improved properties while using less costly ingredients and processing methods.

As part of that effort, scientists in the National Bureau of Standards Metallurgy Division are using experiments and theoretical modeling studies to help decipher not just which metals and alloys possess desired properties, but also how processing variables affect that behavior, and why.

## Rapid Solidification Technology

In a new metals processing facility, Bureau scientists are studying one of the most promising new metals processing methods: rapid solidification. Rapid solidification technology, or RST, involves quenching (freezing) liquid metals or alloys at rates as high as 1 million degrees per second to achieve supercooling* prior to solidification. By solidifying metals so quickly, new alloys can be formed with more refined and homogeneous or even glassy structures which have a number of other improved characteristics—unusual magnetic properties; greater strength, and lighter weight; and more resistance to wear, corrosion, fracture, and high temperatures. (See box.)

Actually, RST is not all that new. Scientists have been experimenting with rapidly quenched metal powders for the past 30 years. Major metal manufacturers have been making complex parts from such powders for the last 10 years. What is new is the realization that rapidly solidified metals have much broader applications with extensions to new alloy compositions and much more promising properties than initial laboratory experiments had indicated.

In a brochure describing the virtues of the process, one company cites the results of recent Government-sponsored research showing a 200 °F (110 °C) improvement in temperature resistance for certain rapidly solidified nickel alloys over superalloys currently used in jet engines. Rapidly solidified lithium/aluminum alloys, very difficult to make with ordinary processing, are said to weigh 30 percent less, yet are about 100 times more resistant to cyclic stress than conventional aluminum alloys. Rapidly solidified stainless steel, states the brochure, can be made without any chromium—yet the RST chromium-free alloy weighs 20 percent less and can safely withstand temperatures 200 °F higher than the chromium-containing alloys now used.

Like many emerging techniques however, RST has several problems that must be solved before truly widespread application of the technology can be realized.

"People can't really predict and precisely control rapid solidification processes yet," says John Manning, leader of the metallurgical processing group within the NBS Metallurgy Division. "We're trying to understand the mechanisms by which you arrive at these unusual alloy microstructures. How fast do you have to quench a liquid metal to get a glassy structure? What parameters are important?"

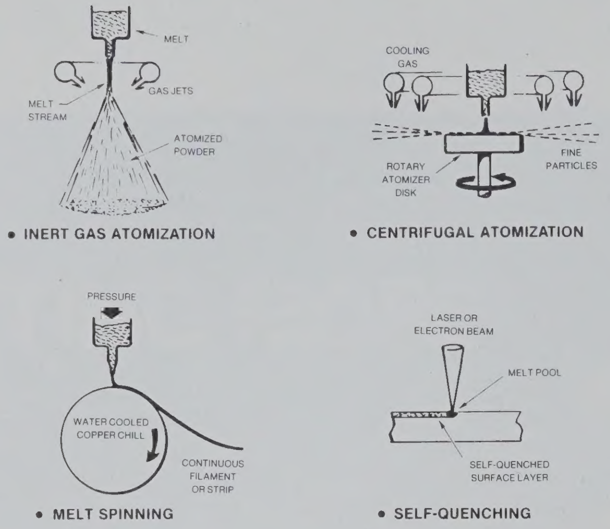
"We know," adds Robert Shull, a metallurgist in Manning's group, "that you can make RST alloys by quenching at 1 million °C per second, but can you also make them at 10,000 °C per second or 1,000 °C per second?"

NBS metallurgist William Boettinger set out to answer such questions when he designed an experimental apparatus to produce a special rapidly solidified alloy made of palladium, silicon, and copper. His apparatus holds a hollow glass tube filled with the liquid alloy and then plunges the tube into liquid gallium at various constant speeds. This causes solidification at different rates from the bottom to the top of the column of metal. In very carefully controlled experiments, Boettinger found

---

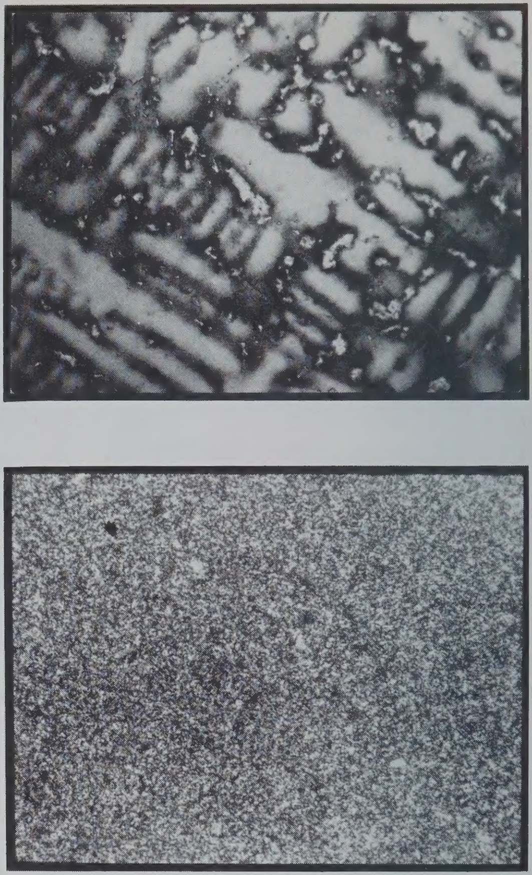
*Porter is a writer and public information specialist in the Public Information Division.*

* *Cooling at about 30 to 40 percent below a metal's absolute melting point.*



- INERT GAS ATOMIZATION
- CENTRIFUGAL ATOMIZATION
- MELT SPINNING
- SELF-QUENCHING

EXAMPLES OF RAPID SOLIDIFICATION METHODS



*These scanning electron micrographs (SEM) show the difference in microstructure between a conventionally cast superalloy and the same alloy made by rapid solidification. (Magnification for both SEM's is 100X.)*

## WHAT'S SO GOOD ABOUT RST?

To understand why rapidly solidified alloys possess such a wealth of good properties like high strength and resistance to corrosion, fracture, high temperature, and wear, it helps to compare the way they are formed with the conventional method of producing alloys.

An ordinary alloy starts out as a homogeneous mixture of two or more liquid metals. However, during solidification crystals begin to form and the various metals will tend to "segregate" or separate from one another. Copper atoms prefer to bond with other copper atoms, aluminum with other aluminum atoms, and so forth. The end result is that most conventional alloys look like a patchwork quilt when viewed under the scanning electron microscope. Large crystal groups or grains and "precipitates" or pockets of relatively pure metal are easily seen.

An RST alloy, on the other hand, is solidified so quickly and at such low temperatures, that large crystal groups and large precipitates do not have time to form. When viewed at the same magnification as a conventionally produced alloy, the RST specimen looks smooth and uniform in comparison. Moreover, increasing the chemical uniformity by rapid solidification means the RST alloy is less susceptible to corrosion and fracture.

There is a hitch, however. To get something very hot, like a liquid metal, to freeze very quickly, only very small amounts can be cooled at a time. (A spoonful of soup cools much faster than the soup in the bowl.)

There are three basic ways for producing rapidly solidified metals and all of them depend on this principle. The most extensively researched technique involves forming metal powders by either atomization or by pouring liquid metal onto a rapidly spinning disk. In the second case, for example, the liquid metal is sprayed out in the form of tiny spherical droplets that freeze when struck by high speed jets of helium gas. The process forms frozen droplets or powder that can later be fused into the shape of a metal part.

The second technique uses a rapidly spinning wheel maintained at extremely low temperatures. A thin column of liquid metal is poured onto the edge of the wheel, where it freezes instantly in the form of a continuous thin ribbon or wire. Because of vastly improved magnetic properties, such RST materials may have applications in the manufacture of transformers for electrical systems.

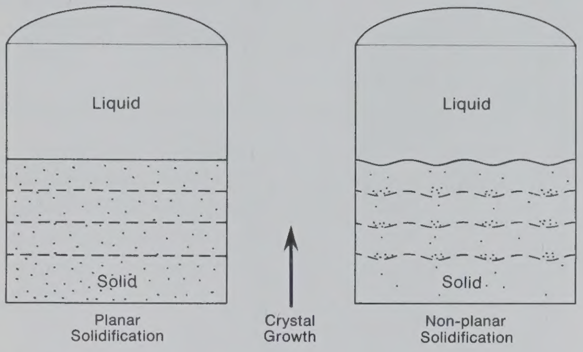
The third method creates a very thin layer of rapidly solidified metal on the surface of a conventionally produced metal part. An intense laser or electron beam is scanned rapidly across the surface of the part, causing a thin layer of metal to melt. The bulk metal beneath the melted portion siphons away heat as soon as the beam moves away, leaving a more homogeneous RST layer in place of the original alloy surface. This method might also be used to produce metal-nonmetal composite RST surfaces. As the high-energy beam is melting a surface layer, a powdered ceramic compound can be added. When the metal solidifies, the ceramic grains are fastened in place, producing a strong alloy part with improved wear properties.

that when the interface between the solid and liquid part of the alloy moved at speeds of less than 1 millimeter per second, a conventional crystalline alloy structure was formed, but when the solid/liquid interface reached velocities greater than 2 millimeters per second, an amorphous or glassy structure was produced. For this alloy, this translates to a cooling rate of only about 100 °C per second.

Boettinger's initial experiments of this type, completed during 1980, were among the first to establish precisely the critical solid/liquid interface velocity needed to produce a glassy structure for a particular alloy composition. These experiments also helped to show that the cooling speed is the most important factor determining the ultimate structure (or lack of structure) of an alloy. Prior to Boettinger's measurements, many metallurgists believed that glassy metals formed only when there were no crystallized "nuclei" present to begin the crystallization process. Clearly, as the palladium-silicon-copper solidified within the glass tube at faster and faster rates, nuclei were present to begin crystallization of the remaining liquid alloy; yet, as soon as the solidification rate reached sufficient speed, a glassy alloy was formed.

Such results offer tempting conclusions. Even though palladium-silicon-copper is admittedly a very special alloy, unsuitable for commercial uses, the fact that glassy metals can be formed at lower cooling rates than originally thought, "opens up the possibility of producing much thicker forms than now possible," says Robert Mehrabian, chief of the NBS Metallurgy Division. "In the future," he continues, "it may also be possible to start with pulverized glassy structures, transform them to homogeneous microcrystalline structures, and then put the particulates together to produce a 'massive' metal part . . . . Here, the glassy phase is used as a 'pathway' to production of a large, homogeneous crystalline part."

Another question metals researchers would like to have answered is, "What does the solid/liquid interface actually look like as an alloy is solidifying?" NBS theoretician Sam Coriell has calculated that, for a particular alloy of aluminum and silver, the solidification interface should be planar or straight at very slow velocities, wavy at intermediate velocities, and then planar again at rapid solidification speeds. If his theory can be validated experimentally, it could provide an excellent method for predicting the type of settling out or precipitation that will occur at different solidification rates.



*As represented in this diagram, a wavy solidification interface would be expected to concentrate impurities at the troughs of the wave front, while a planar interface should create a more homogenous structure.*

In general, says Manning, a wavy solidification interface (see diagram) tends to concentrate impurities or minor alloy constituents at the troughs of the wave front, while a planar interface forms a more homogeneous structure. With a reliable predictive model, he says, alloy compositions and solidification speeds could be selected to create precipitates of just the right size to produce desired properties in a finished metal product.

A high-voltage, electron beam scanning system developed by NBS metallurgist Robert Schaefer is now being used to test Coriell's predictions. Depending on how powerful an electron beam is used and how fast the beam is scanned across a specimen, different surface microstructures can be created. Tests to date, says Schaefer, have produced RST surfaces on aluminum alloy and stainless steel samples. This type of system is ideal for testing the validity of Coriell's theoretical model because of the simplicity of heat flow.

"With the scanning method," says Schaefer, "we can determine exactly where and when the energy is applied, and we can calculate with confidence the rate at which the energy is transferred into the bulk of the sample." This allows a straightforward calculation of the exact rate at which the surface resolidifies. The solidification rate can then be correlated precisely with the resulting microstructure formed on the surface and ultimately compared with the theory.

Shull is gathering similar experimental information for application to the production of rapidly solidified ribbons by melt spinning. Using zirconium, an alloy of copper, he is trying to establish the importance of several parameters such as the temperature of the liquid alloy before it hits a

*NBS metallurgist William Boettinger describes an apparatus he designed to measure precisely the solidification rate required to produce an alloy of palladium-copper-silicon with a glassy microstructure. The glass tube at the bottom of the metal rod is filled with molten metal and then plunged at various constant speeds into liquid gallium.*

spinning wheel, the width of the metal column as it is poured, and the temperature and speed of the wheel. "We also want to know what materials we can make in the glassy state using this method," he says, "and we are studying the constraints on glass formation under optimal processing conditions in a series of different alloy systems."

Even though practical methods for rapidly solidifying metals have been known for about 10 years, says Mehrabian, there is still much to be learned about which metal combinations are the easiest and most useful RST alloys to produce. In looking for the answers to such questions, he says, "we're hoping to improve on the old Edisonian approach. We're trying to provide the kind of information needed to get rid of trial and error experimentation as much as possible."

## Phase Diagrams and Diffusion

This goal applies as well to the development of new alloys other than those formed by rapid solidification. Designing new alloys, whether for conventional production or rapid solidification, however, is anything but easy. The relationships and bonding patterns between metals are very intricate affairs.

Since the 1800's metallurgists have used something called an alloy phase diagram to improve the predictability of metals behavior. "A phase diagram," says Mehrabian, "is a map that tells you what crystal structure exists at what compositions and at what temperatures. Advancement in the understanding and dissemination of phase diagrams is an essential step in the development of new alloys."

According to Joanne Murray, a theoretician in the chemical metallurgy group, the "Bible" of phase diagrams was compiled by German metallurgist Max Hansen during the 1950's. Since then many researchers have contributed to the phase diagram literature, she says, but "there really hasn't been a comprehensive re-evaluation."

With Don Orser and David Redmiles of the NBS Applied Mathematics Division, Murray has developed a computer graphics system that converts raw data from experimental research or from calculations based on thermodynamic predictions, into a completed phase diagram. This effort is part of a cooperative program with the American Society for Metals (ASM) to provide a centralized computer bank of up-to-date phase diagrams that could be easily accessed by researchers.

"We're thinking on a grand scale," says Murray. "We want to develop a complete data bank of phase stability information: experimental data, evaluated phase diagrams, annotated bibliographies, thermodynamic data—the works, all easily retrievable at your terminal." In the past year, she says, they have developed the computer program to draw the diagrams and are now in the midst of the more arduous task of updating and critically evaluating phase diagrams to be included in the data bank.

There are over 4,000 binary or two-element phase diagrams that are important to metallurgists, says Murray, and thousands more for multielement systems. "Fortunately, we at NBS don't have to do them all." People all over the world are cooperating with ASM by updating specific categories of diagrams.

Murray herself is using thermodynamic models to evaluate phase diagrams for 96 different alloys of titanium. Titanium has become a very important metal for the aerospace and shipbuilding industries because of its low weight, high strength, and resistance to corrosion. However, there are still gaps, says Murray, in the phase diagram literature on titanium alloys because, "it's really only in the last 30 years that we've had titanium of sufficient purity to make accurate measurements. Where there are gaps in the literature, we are learning to make thermodynamic calculations to predict how those gaps might be filled."

In addition to establishing a centralized phase diagram data base, researchers in the Metallurgy Division are cooperating with ASM in publishing the *Bulletin of Alloy Phase Diagrams*, a quarterly newsletter containing recent phase diagram data. Metallurgists who receive the *Bulletin* have an opportunity to evaluate critically new experimental results to help assure that only the most reliable data are incorporated into the scientific reference literature.

Complementing these two programs is a third data-gathering effort centered on quantifying the metallurgical property known as diffusion. Metals having different atomic sizes and properties will diffuse or mix with one another at different speeds. Data describing diffusion behavior are important for designing many types of metallurgical processes such as heat treatments to decrease undesirable alloy segregation or to produce improved alloyed coating systems. The NBS Diffusion in Metals Data Center maintains extensive files of critically evaluated diffusion data and produces new research where needed to meet the needs of specific industries. A current program with the International Copper Research Association, for example, involves compiling diffusion data for selected copper alloy systems.

### Controlling Manufacturing Methods

Designing new alloys or processing methods is not the only way to improve the productivity and quality of metals manufacturing. Significant savings in energy and improvements in quality can be made by better control of manufacturing methods already in use.

Increased use of ultrasonic inspection methods throughout the processing cycle offers one potential means to this end. Ultrasonic inspection is by now a common nondestructive evaluation technique used in the aerospace and other industries to find cracks or flaws in alloy plates or finished parts. NBS researchers are now trying to adapt the technique to examine the microstructure and thus the hardness and strength of alloys, as well.

These kinds of measurements are now made either nondestructively with eddy current measurement or with destructive tests where alloys are actually dented (hardness) or fractured (yield strength). The destructive tests have obvious drawbacks. The eddy current technique is widely used and entails measuring differences in electrical conductivity between alloys processed in different

*Robert Schaefer, a Bureau metallurgist, and John Manning, leader of the metallurgical processing group within the NBS Metallurgy Division, examine the rapidly solidified surface produced on a conventional aluminum alloy after it was scanned with the electron beam apparatus in the background.*

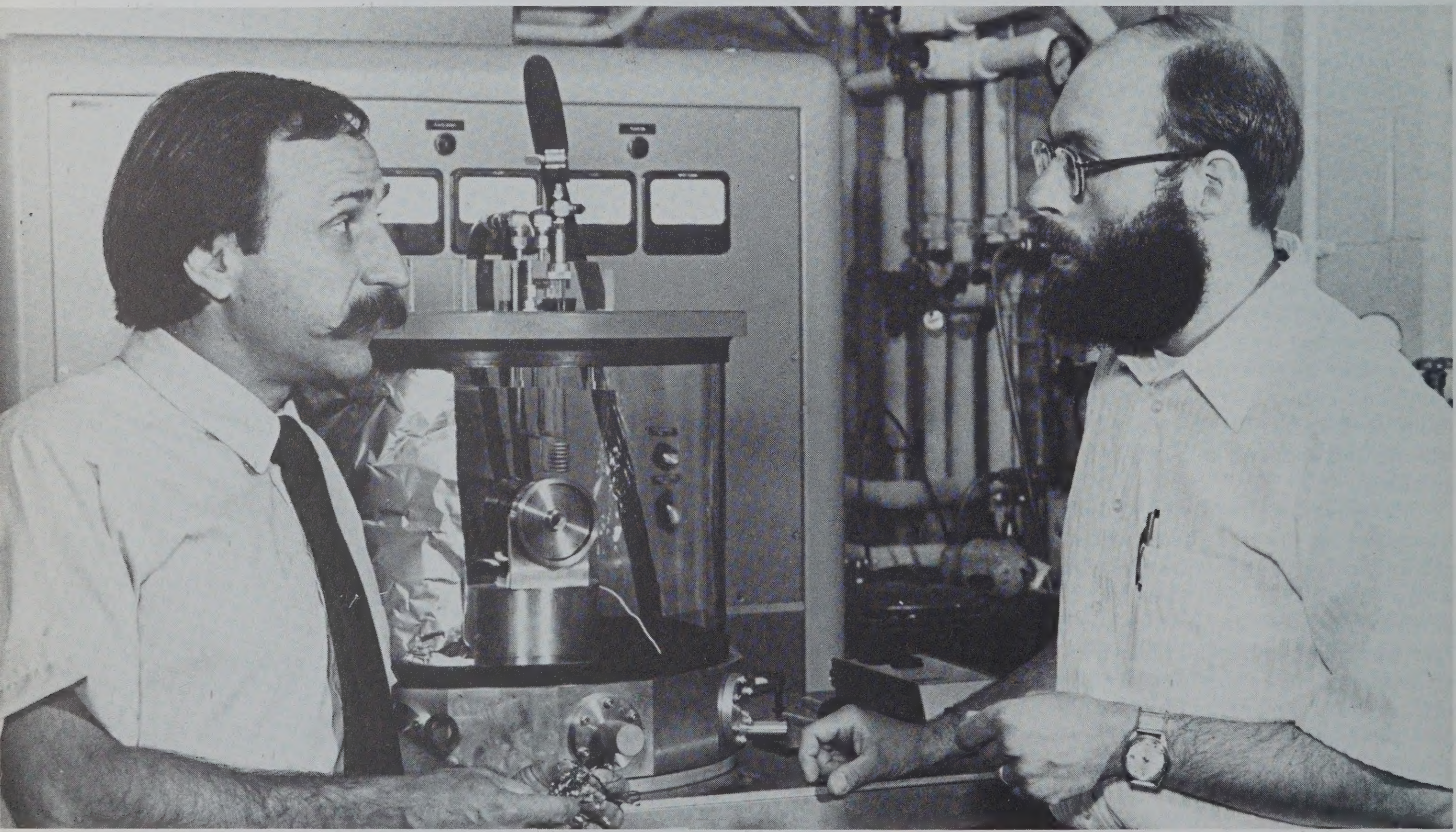
ways. However, according to Moshe Rosen, a guest worker at NBS from The Johns Hopkins University, eddy current measurements show wide variations across processing temperatures and may not be as reliable a method of alloy strength characterization as originally thought.

In a comprehensive study sponsored by the National Aeronautics and Space Administration, NBS researchers traced in detail the effect of several processing parameters on the microstructure and nondestructive evaluation results obtained for a single alloy, 2219 aluminum. Ingots of 2219 aluminum cast in the metals processing laboratory under precisely monitored conditions were subjected to a full range of characterization tests. Scanning electron and transmission microscopy revealed the basic microstructure and chemical composition at different locations within the ingots, while destructive yield strength and hardness measurements were correlated to eddy current measurements through round robin tests by four different laboratories.

The final report describing this project* concludes that because eddy current testing is basically a surface or near-surface technique, a number of processing treatments will affect these measurements in ways unrelated to the alloy's overall properties. Ultrasound waves, on the other hand, says Rosen, can be passed through the entire thickness of an alloy plate. His preliminary results with

---

* *Nondestructive Evaluation of Nonuniformities in 2219 Aluminum Alloy Plate (NBSIR 80-2069). Available for $18.50 prepaid through the National Technical Information Service, Springfield, Va. 22161. Use PB #81-172348.*



*Robert Mehrabian, chief of the NBS Metallurgy Division, and Robert Shull, an NBS metallurgist, discuss Bureau efforts to define and quantify the most important parameters in the production of rapidly solidified metal ribbons.*

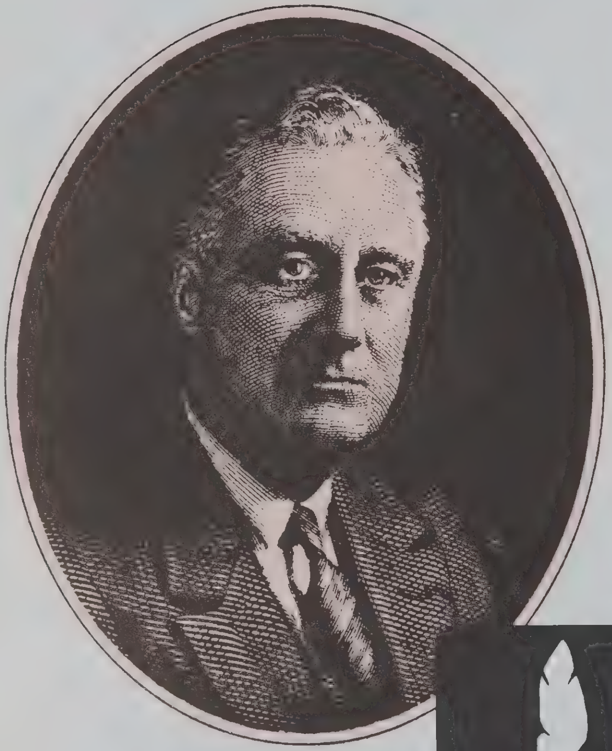
2219 aluminum show that the attenuation (weakening) and velocity of a reflected ultrasonic wave correlates directly with hardness measurements. With a real-time feedback system, Rosen envisions aluminum manufacturers using ultrasound to characterize the microstructure of alloy plates during production. Ultrasound generators and detectors could be positioned at the final stage of plate manufacture called precipitation age hardening. This is where the initially quenched alloy plate is reheated to produce precipitates in the correct size range for strengthening. When the shape and velocity of ultrasound pulses indicate the desired alloy microstructure, a computer system, says Rosen, could be programmed to adjust heating and cooling systems accordingly. This would save considerable energy while producing a more carefully processed alloy plate.

The same principles could also be applied, says Metallurgy Division staff member Robert Parker, to monitor the liquid/solid interface of an alloy plate at a continuous casting plant. Parker has used the type of ultrasound pulse systems employed in flaw detection to determine the speed and location of liquid/solid interfaces in pure tin samples during solidification.

With a computer-operated feedback system similar to the one described above, says Parker, manufacturers could change processing temperatures and quenching speeds immediately to produce alloys with the correct phase structure and segregation. While the concept of using ultrasound measurements in continuous casting processes is not new, Parker says he believes recent improvements in microprocessor-based computer systems and in ultrasonic detectors now make application of this technique more practical.

This really is the theme of much of the metals processing research and development work being proposed for full-scale use in the factory. The days of cheap energy and raw materials seem gone forever, while the ability to predict and automate production processes has increased steadily. This combination of factors may be just what is needed to foster dramatically improved productivity for the metals industry as well as for the major consumers of metals, such as the aerospace, automobile, and electrical industries. The "gold" created in the process may not be the type coveted by alchemists, but in today's cost-conscious business climate it would be just as welcome. ☐

*Bureau metallurgists William Boettinger and Frank Biancaniello pour molten aluminum/copper into a special plaster cast as part of a study of heat flow and its effect on alloy segregation.*



# preserving the past: NBS studies film and tape deterioration

by Emily B. Rudin

### Research Associate Program at NBS

LISTENING to an old recording of one of Franklin D. Roosevelt's famed fireside chats, you hear history's 40 years of cracks, pops, and hisses, and pray that the aging process will not, one day, drown out the President's message altogether.

You are not alone in this concern. The National Bureau of Standards has begun research to determine how microfilm and magnetic tape deteriorate.

Sponsored by the National Archives, the Bureau's study will provide data to suggest optimal storage conditions for these materials. NBS will also develop test methods for estimating the materials' remaining useful storage life.

For many years, paper has been the primary medium for documents, records, and transactions of all kinds. But the proliferation of paper in recent times has created severe limitations in available storage space. New polymer-based media, such as microfilm and magnetic tape (video and audio) and electrographic materials, have taken a strong hold in the domain ruled by paper, and afford much higher-density storage. Archives, libraries, and data

---

*Rudin is a writer and public information specialist in the NBS Public Information Division.*

centers everywhere are facing the fact that technology is changing, with dramatic speed, from paper to polymer.

With this change to polymers comes a challenge: how to preserve them. The synthetic polymer used as a base in these new media is known to be very stable. Less is known, however, about the polymer's lifetime under varying environmental conditions, its specific characteristics, or ways to assess the relative condition of a film or tape.

Manufacturers of magnetic tape and photographic film have always been concerned with the stability of polymer-based materials, but primarily within the limits of the normal needs of business consumers. The NBS project focuses exclusively on the performance of these materials for archival use. Thus, while commercial needs might require that a polymer-based material—say, a personnel record—last a maximum of 10 to 50 years, a public archive might look to an ideal lifetime of 100 to 500 years. An understanding of polymer-based media and the use of proper storage techniques can help preserve such artifacts as historic war footage, network newsreels from the day John F. Kennedy was shot, and notable concert performances.

The National Archives is the Federal repository for documents of national interest, including legal copies of congressional bills, original treaties, and the U.S. Declaration of Independence and the Constitution. Presidential libraries, in fact, are also administered by the National Archives.

NBS researchers, however, "are more interested in preservation techniques for high-volume records, not for the highly visible documents the public knows best," says Leslie E. Smith, the project's leader in the Polymer Science and Standards Division.

Since the Archives receives its holdings from other sources, it must determine the condition of the materials and must know how to store them effectively.

How can you tell good tapes and films from bad? How do you determine proper storage conditions? How can you keep future problems in storing and preserving the materials at a manageable level? The NBS project will provide a technical basis for answering these questions, and will develop techniques to enable Archives technicians to perform the increasingly vital task of sorting out good tapes from unserviceable ones. "The tests we eventually develop will need to be simple enough to be run in an archival laboratory with readily available equipment," Smith notes.

In its years of experience with paper, the Archives has learned the best conditions of temperature and humidity for many different stocks. But the less-known synthetic polymers pose a problem. Besides temperature and humidity, they are sensitive to air pollutants (sulfur dioxide, airborne acids, nitrous oxides) and microbial attacks by mold and fungus. A preliminary finding of the NBS study has also revealed that polymers are subject to hydrolysis (decomposition) by water; thus the optimal storage humidity must be lower than for paper.

Although the storage characteristics of polymer-based media represent a new research frontier, the Bureau is launching its study none too soon. Just 3 or 4 years from now, Smith predicts, the sheer volume of tapes that the Archives accumulates will be so enormous that recopying all tapes at regular intervals will become prohibitively expensive.

The NBS Polymer Science and Standards Division is no stranger to historical preservation of polymers. In 1950, it developed the controlled system for storing and displaying the Declaration of Independence and the Constitution at the Archives. These documents are paper, composed of natural polymers. ☐

# NBS Research Forges STRONG LINK with Industry

## Research Associate Program at NBS

By now, you probably know the new buzzwords in every business leader's prescription for the Nation's economic health: "industrial productivity," "innovation," "efficiency," and "strength in the international marketplace."

To help fuel the progress of American industry, the National Bureau of Standards is gearing up its Research Associate Program. For the last 60 years, this program has enabled industry and NBS to pursue dozens of research projects of mutual interest. The Bureau is now inviting companies to participate in new areas of interest to industry, including materials processing, automation, electronics, and chemical engineering.

Through the program, NBS is now hosting about 100 scientists and engineers from private companies, trade and professional associations, and other organizations. With their salaries paid by sponsoring employers or organizations, the associates work on a wide range of research, including robotics, electromagnetic interference, fire safety, nondestructive evaluation, and dental materials.

The interaction is a two-way street. Research associates can benefit from the use of NBS facilities and from the opportunity to consult in person with the diverse NBS professional staff. They then can take newly developed technology back to their organizations for prompt application. NBS gains from the program by learning firsthand the views and needs of the industrial community.

"The program is a great way for NBS to strengthen its working ties with industry," says Peter de Bruyn, NBS industrial liaison officer and coordinator of the program since 1966. "We welcome having researchers and managers tell us how they would like to work with us."

What are some ways NBS is already cooperating with industry? Here are examples of three successful research associate projects.

## Toward Better Electrical Transmission

The puzzle of why materials fail is a crucial problem in the electrical industry.

Eric Forster is a scientist from the Exxon Research and Engineering Company in New Jersey, working in the Bureau's Electrosystems Division. "As an NBS research associate," he says, "I am trying to learn in detail—with a time resolution of one-billionth of a second—about the failure process in liquids that insulate high-voltage electrical equipment."

The Exxon-NBS program pairs the Bureau's interest in measurement apparatus and techniques with Exxon's chemical interests. Based on an innovative NBS measurement technique, the work aims to help industry better predict and control energy losses during electrical transmission and distribution and to design and construct more reliable high-voltage apparatus.

"Working together, we have improved our understanding of this problem," says Robert Hebner, Forster's NBS colleague on the project. The collaboration has enabled both to join skills, resources, and intelligence in pursuing a research problem that each acknowledges could not have been successfully confronted alone.

The project, which began in August 1980, has been extended to August 1982.

## Metal Standards for Quality Control

Another active project has enjoyed 5 years of success. NBS is collaborating with the American Society for Testing and Materials, which is comprised largely of industrial researchers and managers, on a project to provide Standard Reference Materials, or SRM's, in response to current and future needs of the metals industries.

Metal SRM's—first provided by NBS in 1906—are certified standard samples that industrial producers and consumers use to standardize their test procedures and to check the accuracy of their

*Researchers examine a low-alloy steel SRM used to calibrate optical-emission equipment. The SRM was certified in 1981 through the collaboration of Research Associates James Shultz (far left) and Rosemond Bell (far right) and NBS colleagues Robert Michaelis (left center) and George Uriano.*

instruments. Precise measurements in the metals industries are important because metal-based products are bought and sold on the basis of carefully controlled composition specifications. Measurement errors can mean that a stainless steel part that does not meet strict composition standards might fail in actual use.

Thus, metals industries are vitally interested in maintaining the supply of metal and ore SRM's. Representatives of many companies are members of the ASTM committees sponsoring research associate James I. Shultz and an assistant research associate, Rosemond K. Bell. Both are chemists working with Robert E. Michaelis of NBS to provide the many metal SRM's needed by industry.

"More than 100 SRM's have been characterized and certified," Shultz says", and probably another 100 are in the planning stage." ASTM helps guide the priorities of the program according to industry's needs, and NBS works those priorities into its certification plan. Thus, the Bureau's SRM program can respond directly to a critical need—say, for low-alloy steel SRM's—as opposed to something in less demand.

George A. Uriano, who is in charge of the SRM program, says that the cooperative program "has been vital in enabling NBS to keep up with industry's demand for SRM's. It is so successful, in fact, that it is now serving as a model for two other ASTM-sponsored research associate projects to provide SRM's for glass and fine particle technology."

*Research Associate Dolan Toth (left) and NBS colleagues Bill Burr (center) and John Riganati discuss draft specifications for a high-speed computer channel interface.*

**The Computer Connection**

In just a few years, computer interface technology will make it possible for any computer to communicate with any other computer, creating a sort of international language by which computers can "talk" to each other.

At the Bureau's Institute for Computer Sciences and Technology, a research associate project on this subject is in full swing with the Control Data Corporation of Bloomington, Minn. With the cooperation and support of industry, the program is helping to develop standards for high-speed channel interfaces—areas of interconnection within a computer system, such as the places where a peripheral device, like a disk or tape unit, is connected to the central processor of the computer. Because new and faster ways of transmitting signals—like fiber optics—are beginning to replace older wiring, the project is focusing on this new technology.

Computer companies can benefit from working with NBS because they can help shape future Federal Information Processing Standards that guide agencies in purchasing and using computers economically and efficiently.

NBS, in turn, wants to collaborate with commercial firms because they have the state-of-the-art expertise that will be helping to build the computers of the mid-1980's.

Says the Bureau's John Riganati, "Our progress has been enhanced by contributions from people in industry and by the fact that people on all sides are actively interested in this work. Everyone wants a standard, and none exists right now."

Research associate Dolan Toth of Control Data echoes Riganati's views. "The cooperative program is accelerating the state-of-the-art for interface technology and standards," he says. "We're more than halfway there."

Toth and his NBS colleagues believe the mutually beneficial working relationship they have enjoyed will result in standards that will be accepted and supported by both Government and private industry.

**An Invitation from NBS**

These are only three of the successful projects in the Research Associate Program at NBS. Companies and trade and professional organizations interested in the NBS Research Associate Program are invited to contact Peter de Bruyn, Industrial Liaison Officer, National Bureau of Standards, Washington, DC 20234 (301/921-3591). E. R. ☐

## NEW NBS INSTRUMENT MONITORS ELECTROMAGNETIC RADIATION

*by Fred McGehan*

Private industry and Government agencies, including the military, that are concerned with electromagnetic interference and hazards will be interested in a new instrument for monitoring electromagnetic radiation.

Developed by the National Bureau of Standards, the isotropic electric-field monitor (EFM-5), was developed to meet the needs for measuring electromagnetic radiation in a variety of circumstances. The EFM-5 provides for the first time in a survey instrument a frequency range covering the AM, FM, and TV broadcast bands. It also responds to a wide range of signal strengths. More specifically, with an accuracy of ±2 dB, the instrument covers the frequency range 200 kHz to 1000 MHz, which includes many broadcasting bands as well as special industrial applications—such as radio-frequency heat sealers and curers.

With the original goal of developing an instrument that could be marketed commercially, the NBS designers of the EFM-5 used readily available components and a system which is amenable to conversion for production. One company has already taken advantage of this opportunity and now offers a commercial version of the EFM-5 as a catalog item; several other companies having similar marketplace interests have been in contact with NBS.

In terms of its dynamic range, the EFM-5 can monitor electromagnetic fields on the order of 1 volt/meter, such as those produced by a broadcasting antenna at moderate distance from the antenna; such fields may produce interference or electromagnetic "smog" problems. The instrument can also measure electromagnetic fields as high as 1000 volts/meter, sufficient to monitor electromagnetic leakage at close quarters (e.g., within 5 centimeters, or 2 inches) from devices such as medical diathermy equipment, plastic, sealers, and chambers for drying and curing materials.

The EFM-5 is completely self-contained and portable and is intended for use by one person in a variety of environments. The instrument consists of a probe (basically three mutually perpendicular dipoles, detectors, and filters), an electronic measuring and readout instrument, and a special high-resistance plastic transmission line which minimizes the EFM-5 disturbance of the field being measured.

The EFM-5 is described in *Design and Calibration of the NBS Isotropic Electric-Field Monitor (EFM-5), 0.2 to 1000 MHz* (TN 1033), which provides specifications and design, calibration, and performance data. This information is offered without patent restrictions, and NBS encourages others to make full use of the data.

Copies of the report are available for $4.50 prepaid from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Order by Stock No. 003-003-02311-6.

*Ezra B. Larsen, a physicist with the Electromagnetic Fields Division, calibrates the isotropic electric-field monitor (EFM-5) in a transverse electromagnetic (TEM) cell. Larsen inserts the probe into the calibration chamber; a teflon line links the probe with the metric box in the foreground.*

---

*McGehan is a writer and public information specialist in the NBS Boulder Program Information Office.*

## VERIFICATION PROCEDURES FOR FEDERAL INTERFACE STANDARDS

*by Stan Lichtenstein*

New procedures for placing computer equipment on a verification list for Federal I/O channel level interface standards have been announced by the National Bureau of Standards.

In addition to existing procedures for reviewing documentation of equipment interfaces for conformance to the standards, NBS will expand its verification service to include the following:

- verification through documented operational use in conjunction with equipment already on the verification list;
- verification through documented demonstration in conjunction with equipment already on the verification list.

Suppliers interested in placing their equipment on the verification list now have the option of requesting verification by any of the three methods. Requests for verification, copies of the verification list, or information concerning the service may be sent to the Director, Institute for Computer Sciences and Technology, National Bureau of Standards, Washington, DC 20234; Attention: I/O Channel Equipment Verification. Telephone Marshall Abrams at 301/921-3723 for additional information.

Equipment that NBS verifies to be in conformance with the standards may be procured by Federal agencies. The four interface standards apply to procurement solicitations and orders for medium- and large-scale computer systems and peripheral devices to be connected as part of these systems, unless a waiver has been obtained from the Secretary of Commerce.

These standards are:

- FIPS PUB 60-1, *I/O Channel Level Interface,*
- FIPS PUB 61, *Channel Level Power Control Interface,*
- FIPS PUB 62, *Operational Specifications for Magnetic Tape Subsystems,* and
- FIPS PUB 63, *Operational Specifications for Rotating Mass Storage Subsystems.*

To satisfy the requirements for demonstrating successful operational use in conjunction with equipment already on the verification list, equipment must be used primarily for processing information. It must be in operational use long enough to establish satisfactory performance, and the configuration of the computer system must clearly demonstrate the functional capability of the equipment. Further, the equipment must be operational in more than one installation.

To satisfy the requirements for documented demonstration in conjunction with equipment already on the verification list, suppliers must demonstrate conformance with all of the applicable provisions of the standards. The tests used must be sufficient to demonstrate correct operation of the equipment when it receives sequences of correct signals and appropriate response to incorrect signals.

The Bureau's general policies for test procedures are specified in Part 200 of Title 15, Code of Federal Regulations, and in *Calibration and Related Measurement Services of the National Bureau of Standards* (SP 250) available for $3 prepaid from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. (Order by Stock No. 003-003-01916-0.) FIPS PUB's 60-1, 61, 62, and 63 are available from the National Technical Information Service, Springfield, VA 22161; telephone 703/557-4650.

---

*Lichtenstein is a writer and public information specialist in the NBS Public Information Division.*

# STAFF REPORTS

*Scanning Technique, page 17*
*Spin Dependent, page 18*
*Detection of PAH's, page 20*
*Copper "Benchmark" SRM's, page 20*

## HYBRID PLANAR-CYLINDRICAL SCANNING TECHNIQUE DEVELOPED

*NBS scientists have developed a new near-field measurement technique for determining the far-field pattern of an antenna having significant sidelobes. This hybrid technique combines earlier near-field measurement methods, known as planar and cylindrical scanning.* It maps the pattern over wider angles (measured from the axis of propagation of the main beam) than may be accomplished through either of the earlier techniques alone.*

*Allen C. Newell, Electromagnetic Fields Division, 4085 Radio Building, Boulder, CO 80303, 303/497-3743.*

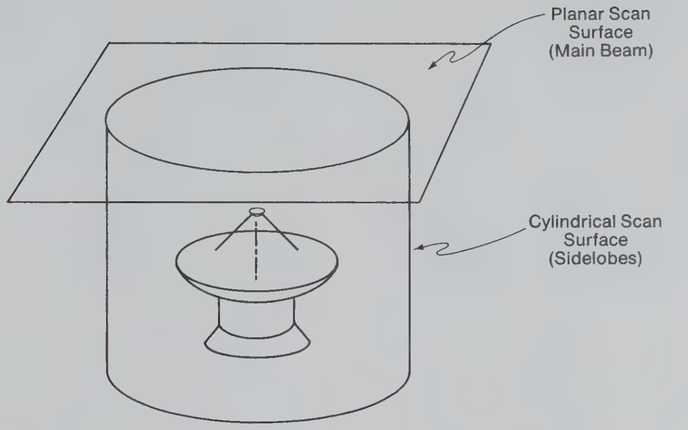
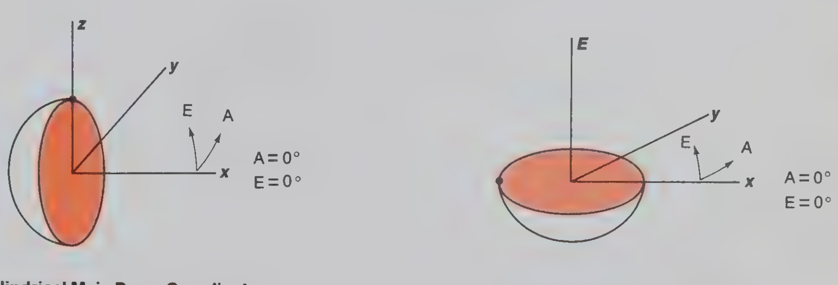

Planar Scan Surface (Main Beam)
Cylindrical Scan Surface (Sidelobes)

**Figure 1**—*Hybrid planar-cylindrical scanning. Main beam region is determined from a planar scan. Sidelobes are determined from a cylindrical scan.*



**Cylindrical Main Beam Coordinates**

**Cylindrical Sidelobe Coordinates**

**Figure 2**—*Comparison of far-field coordinates systems for CMB and CSL scan.*

One of the limitations of planar scanning for certain applications is that reliable far-field patterns are obtained only over a solid angular region extending from the antenna to the far field and defined by the effective edges of the antenna and the edges of the near-field scan plane. This limitation implies that very large scan planes are required to determine far-field patterns over regions approaching a hemisphere.

To extend the region over which far-fields may be determined, a cylindrical near-field scan is carried out with the antenna oriented so that its boresight coincides with the cylindrical scanning axis to obtain the radiation pattern in the far-sidelobe region, and planar near-field techniques are used to obtain the pattern in the main beam and first few sidelobes. The resulting information characterizes the antenna pattern in space except for a conical region centered on the cylindrical scan axis and lying in the rear hemisphere of the antenna. Figure 1 illustrates the scan surfaces for this hybrid technique.

The success of this system depends on whether or not the scan cylinder surrounding the antenna can be truncated in the direction of the main beam of the test antenna in a manner that permits reasonable data to be obtained from measurement sites near the intersection of the scan plane and the scan cylinder. To study the effect of truncation, cylindrical scans were made on a 16-wave-length-diameter reflector antenna in two orientations as shown in Figure 2.

For the cylindrical main-beam (CMB) measurements, the antenna boresight was normal to the axis of the scanning cylinder. For the cylindrical sidelobe (CSL) measurements under investigation, the antenna was oriented with the boresight parallel to the axis of the scanning cylinder. Tests were made using several types of probes, including open-ended waveguides, small standard gain horns, and a horn with an axis tilted with respect to the normal to the scan axis.

---

** Planar scanning refers to a measurement in which a small probe antenna is used to measure the near-field amplitude and phase of a test antenna on a planar surface. Most often, data are required on a rectangular grid. In cylindrical scanning, the measurement surface is a cylinder with data acquired on a grid of points equally spaced in the cylindrical coordinates $\phi$ and z. Most often, cylindrical scanning is accomplished by moving the probe antenna along a vertical line and stepping the antenna in azimuth.*

*In both planar and cylindrical scanning, the far-field pattern is computed from the near-field data and the characteristics of the probe antenna, i.e., correction for the perturbation of the near-field by the probe is included in the calculation. In effect, the hybrid technique determines the main beam and first few sidelobes from planar scanning measurements and the far sidelobes from cylindrical scanning measurements, in which the axis of the scan cylinder is coincident with the boresight of the antenna.*

The coordinate systems for the far-fields obtained from the two cylindrical scans are also shown in Figure 2. Corresponding points on the reflector rim are marked. From this figure we can deduce corresponding cuts in the two coordinate systems. For example, the elevation component, azimuth cut for A > O, obtained from the cylindrical main beam scan, corresponds to the azimuth component in the plane A = 90° with E > O, obtained from the cylindrical sidelobe scan.

Comparisons of amplitude contour plots obtained with CMB and CSL scans are shown in Figure 3. A purely repetitive measurement with both the antenna and probe repositioned would be expected to show agreement to within about 4 dB at –40 dB (referred to the peak power of the main beam). In terms of the complexity involved in making the two scans and converting the CSL far-field pattern coordinates to the CMB coordinates for comparison purposes, agreement is considered to be very good over common regions of validity. Examination of Figure 3 shows a worst case of about 6 dB at –42 dB, near the limits of the common region of validity. These results are interpreted as confirming that the effects of truncation are acceptable and therefore that it is feasible to obtain more complete patterns using the hybrid planar-cylindrical near-field scanning technique than is permitted by either planar or cylindrical scanning alone. An important feature of the technique is that existing planar near-field measurement facilities can be readily adapted to perform hybrid measurements.

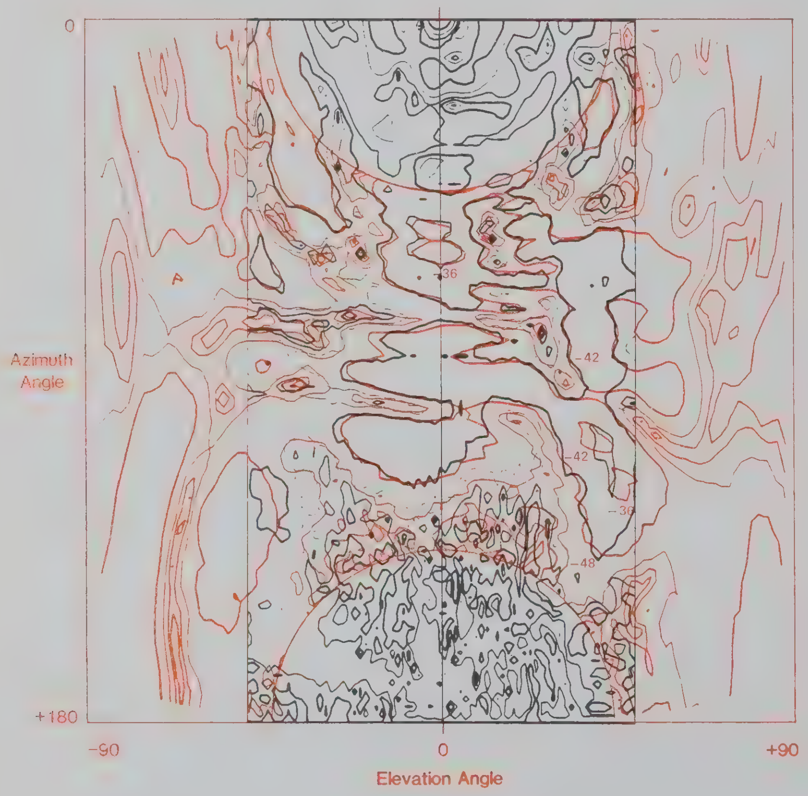


**Figure 3**—*Comparison of amplitude contours obtained from cylindrical main beam (CMB) scan (black) and cylindrical sidelobe (CSL) scan (color). The results for the CMB scan are valid for elevation angles within −50° to +50°. The results for the CSL are valid outside the semicircular regions centered at 0° elevation angle. The limitation in both cases is due to truncation of the scan cylinder, as is explained in the text.*

## SPIN DEPENDENT MEAN FREE PATHS

*Scientists at the National Bureau of Standards have succeeded in calculating the effects due to the electron's spin on the mean free path of electrons in solids, an important quantity for interpreting a broad range of surface-sensitive spin-polarized experiments. These spin-polarized techniques probe the magnetic properties of surface layers that play a role in the design of things as diverse as magnetic information storage systems and catalysts.*

*Ronald W. Rendell and David R. Penn, Radiation Physics Division, B206 Metrology Building, 301/921-2051.*

A variety of measurements, sensitive to the surface region of a solid, are made by observing only those electrons scattered elastically from the solid, i.e., those which emerge with an energy equal to that which they had when they entered the material. Electrons penetrating more than a mean free path λ (typically 5 to 20 A) from the surface are scattered into lower energy states and can be discriminated against. Electrons are found in one of two spin states and, when they travel in a magnetized material, their spin is either parallel or antiparallel to the magnetic field of the solid. Spin up refers to electrons with spin parallel to the magnetization of the sample; spin down denotes spin antiparallel to the magnetization. There will be a difference in the mean free path for electrons of spin up, $\lambda\uparrow$, and spin down, $\lambda\downarrow$, which could have a dramatic effect on the interpretation of surface-sensitive spin-dependent experiments.

We have carried out the first detailed calculations of the spin dependence of λ for Co, Fe, and Ni as a function of electron energy, and have reported the results in *Physical Review Letters.*[1] A convenient measure of the effect of the spin dependence on the mean free path is a quantity A defined by $A = (\lambda\downarrow - \lambda\uparrow)/(\lambda\downarrow + \lambda\uparrow)$. We find the quantity A decreases rapidly in magnitude with increasing electron energy, and eventually changes sign. We also find the magnitude of A to be small and this result, in contradiction to previous suggestions, greatly simplified the analysis of spin dependent results.

---

[1] *R. W. Rendell and D. R. Penn, "Spin Dependence of the Electron Mean Free Path in Fe, Co, and Ni," Phys. Rev. Lett. 3, 2057 (1980).*

For example, Robert Celotta and Daniel Pierce of the NBS Radiation Physics Division have recently carried out experiments in which spin-polarized electrons are directed at a magnetized Ni sample. The electron spin direction is controlled to be either parallel or antiparallel to the magnetization of the Ni. Celotta and Pierce observed those electrons which scattered from the Ni without energy loss and found that the number of scattered electrons depended on their spin direction. This asymmetry could arise from two causes: (1) a difference in the electron mean free path for electrons of different spin direction or (2) a difference in the interaction of the Ni electrons with those in the beam that depends on the spin direction. The first assumption would produce an asymmetry in the scattered electron current because the electron beam travels in the Ni target before being elastically scattered back out. Those electrons which lose energy while in the Ni will not be observed because the experiment is designed to ignore them. Any asymmetry in the way electrons lose energy (i.e., $A \neq 0$) will produce a consequent asymmetry in the observed scattered electrons. In the second explanation, a difference in the elastic scattering of beam electrons by Ni electrons depending on relative spin direction will also cause an asymmetry, and such a difference is known to arise from the so-called exchange interaction. The interaction between two electrons depends on whether their spins are in the same or opposite directions; if their spins are in the same direction they experience an attraction in addition to the repulsive Coulomb interaction, which does not depend on spin.

The very small magnitude of A (shown in Figure 1 for Fe, Co, and Ni) shows that the scattering asymmetry observed by Celotta and Pierce must be due to the asymmetry in the electron-electron interaction caused by the exchange interaction rather than being caused by the difference in the electron mean free paths. A very surprising prediction of our calculation is the change in sign of A as a function of electron beam energy. At high beam energy the sign of A is what one would expect intuitively: The scattering (with energy transfer) of two electrons of parallel spin is weaker than that of two electrons with antiparallel spin due to the exchange interaction. However, at lower energies the solid state behavior of all the electrons in the target becomes dominant and A changes sign.

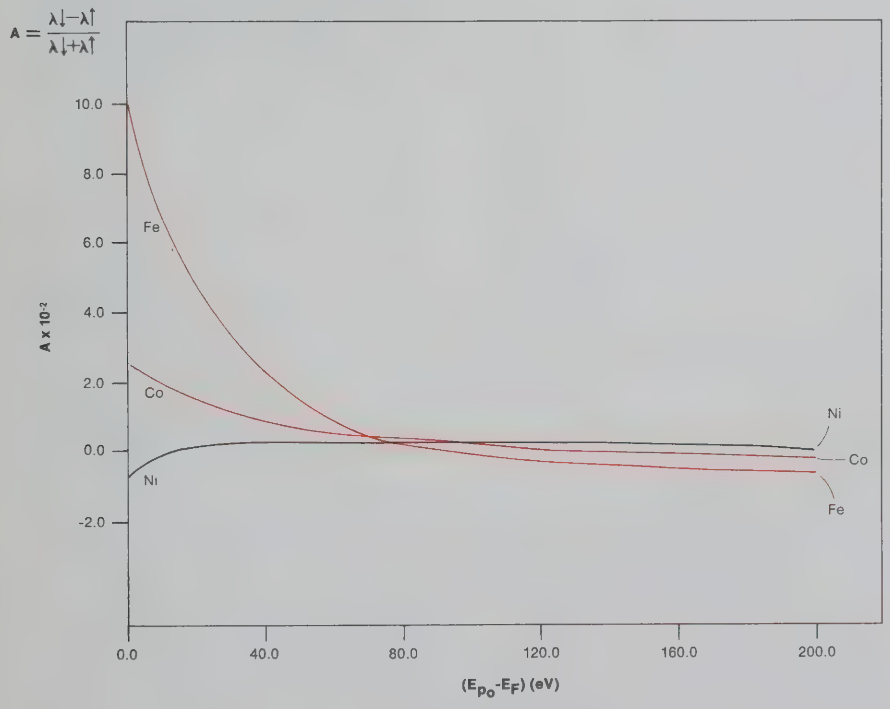


**Figure 1**—*Calculated asymmetry (A) in the inelastic mean free path for incident electrons with spin parallel and antiparallel to the surface magnetization of Fe, Co, and Ni.* $E_{po}$—$E_f$ *is the incident electron energy.*

## NEW SRM AIDS DETECTION OF PAH'S

*A new Standard Reference Material is now available that will help determine the concentration in water samples of polynuclear aromatic hydrocarbons (PAH's). Many PAH compounds are known to be carcinogenic or cocarcinogenic. Their determination in water samples is necessary to assess the environmental hazards associated with the increased use of coal and the development of synthetic fuels.*

SRM 1644, Generator Columns for Polynuclear Aromatic Hydrocarbons, was developed to generate known, accurate concentrations of anthracene, benzo(a)anthracene, and benzo(a)pyrene in water. Accurate concentrations of these low-solubility compounds, that range from 1 to 50 μg/kg (ppb), are difficult to achieve by other techniques.

Anthracene, benzo(a)anthracene, and benzo(a)pyrene were selected to represent PAH's because they have a three-, four-, five-condensed ring structure, respectively, and are among the Environmental Protection Agency's (EPA) priority pollutants. This SRM was requested and partially funded by EPA.

SRM 1644 consists of three stainless steel tubes, each packed with sea sand that is coated with one of the three compounds. In operation, a saturated solution results when water flows through the tube at a rate between 0.1 and 5 mL/min. The aqueous concentrations were determined by methods using high-performance liquid chromatography and fluorescence. These two independent analytical methods gave concordant results. The certificate for this SRM lists the certified concentrations that are obtained when the generator columns are used as directed. The concentrations and their uncertainities are listed in both μg/kg and nmol/L at one degree intervals between 10 and 30 °C.

SRM 1644 is available for $159 from the Office of Standard Reference Materials, B311 Chemistry Building, NBS, Washington, DC 20234, 301/921-3045.

## COPPER "BENCHMARK" SRM'S AVAILABLE

*The Office of Standard Reference Materials at the National Bureau of Standards has recently issued five new copper Standard Reference Materials (SRM's) developed particularly for use in calibration with optical emission methods of analysis.*

Two of the new SRM's, 393, Cu "0," and 454, Cu XI, are for unalloyed copper and are available as fine chips, while SRM's C1251, C1252, and C1253 are of phosphorized copper in the form of chill-cast blocks 32 mm square and 19 mm thick.

These copper "benchmark" SRM's were prepared as part of a cooperative Industry-ASTM-NBS program. They are designed primarily for use in calibration with optical emission methods of analysis, but can also serve in the development of new or improved trace analytical methods of analysis.

SRM 393, Cu "0" is expected to serve as the analytical "blank" for the copper benchmark series. Certification is made for antimony, arsenic, cobalt, copper, lead, nickel, and silver. In addition, "less than" values are provided for 23 elements.

SRM 454, Cu XI, supplements the copper benchmark series for unalloyed copper, particularly for the higher levels of selenium (400 μg/g) and silver (286 μg/g).

The phosphorized copper SRM's, C1251-C1252, have an initial certification of 8 to 12 elements. Additional information on the composition is given for 17 to 21 elements, although these are not certified as yet.

Analyses of the five SRM's were made in six cooperating laboratories and the NBS Inorganic Analytical Research Division.

The prices of the SRM's are:

- SRM 393 and SRM 454 chips, 35 g unit, $98 each.
- C1251, C1252, C1253, chill-cast blocks, 32 mm square by 19 mm thick, $98 each.

They may be purchased from the Office of Standard Reference Materials, B311 Chemistry Building, NBS, Washington, DC 20234; telephone 301/921-2045.

# CONFERENCES

*For general information on NBS conferences, contact Greta Pignone, NBS Public Information Division, Washington, DC 20234, 301/921-2721.*

## EMI MEASUREMENT SEMINAR

The National Bureau of Standards will hold a 3-day technical seminar on the measurement of electromagnetic interference (EMI) at its Boulder, Colo., laboratories from August 25 to 27, 1981.

The seminar, which will combine lectures and laboratory demonstrations, is open to engineers, scientists, technicians, and managers from industry, government, and academia. The purpose of the seminar is to provide these groups with the most up-to-date information on instruments, techniques, and the related theoretical basis for measuring electromagnetic interference.

NBS experts, who have pioneered in the development of EMI measurement techniques, will conduct the seminar. Topics to be covered will include transverse electromagnetic (TEM) cells, open-field testing, anechoic chambers, electromagnetic field probes, remote sensing and scanning units, and enviromental measurement techniques.

To provide maximum interaction for participants, attendance at the seminar will be limited to 40 persons on a first-come, first-served basis. The cost is $595.

## DURABILITY OF BUILDING MATERIALS AND COMPONENTS

More than 50 papers will be presented at the Second International Conference on the Durability of Building Materials and Components, to be held September 14-16, 1981, at the National Bureau of Standards in Gaithersburg, Md. The invited speakers and their topics are:

- Peter Sereda, National Research Council of Canada—Effects of Environment, Microclimate and the Durability of Building Materials
- Dr. Lincoln Hawkins, Consultant, Bell Laboratories, and member of the National Academy of Sciences—Service Life of Polymers
- Dr. Philippe Eurin, Centre Scientifique et Technique du Bâtiment, France—Degradation Processes of Building Materials and Components: A Short Review and Some Proposals for Research
- Edward Berman, President, Edward B. Berman Associates, Inc.—Economic Context for the Cost-Benefit Evaluation of Alternative Levels of Durability in Building Materials
- Tenho Sneck, Technical Research Centre of Finland—Methodologies and Test Methods for Service Life Prediction
- Robert Dillon, National Institute of Building Sciences—Institutional Factors Affecting Durability Performance of Building Materials

Other papers will deal with various aspects of the durability of a wide range of nonmetallic building materials, including paints and coatings, concrete, building stone and terra cotta, polymeric building materials (including fiber-reinforced plastics), wood, gypsum plaster, and roofing materials.

A highlight of the conference will be an address by Dr. Robert Wesson, Assistant Director for Research, U.S. Geological Survey, to be given at the conference banquet on September 14.

For registration information, contact: Barbara Horner, B348 Building Research, NBS, Washington, DC 20234, or 301/921-3458.

# CONFERENCE CALENDAR

### August 10-14

CRYOGENICS—AN ESSENTIAL FOUNDATION FOR ADVANCED TECHNOLOGY, San Diego, CA; sponsored by NBS and Cryogenic Engineering Conference; contact: Dee Belsher, Program Information Office, Room 4001-Building 1, Boulder, CO 80303, 303/497-3981.

### August 19-21

CONFERENCE ON FIRE RESEARCH, NBS, Gaithersburg, MD; sponsored by NBS; contact: Sonya Cherry, B250 Polymers Building, NBS, 301/921-3845.

### September 14-16

SECOND INTERNATIONAL CONFERENCE ON THE DURABILITY OF BUILDING MATERIALS AND COMPONENTS, NBS, Gaithersburg, MD; sponsored by NBS, ASTM, NRC of Canada, International Council for Building Research Studies and Documentation, International Union of Testing and Research Laboratories for Materials and Structures; contact: Geoffrey Frohnsdorff, B348 Technology Building, NBS, 301/921-3485.

### September 24-25

NATIONAL CONFERENCE ON MEDICAL DEVICES STANDARDS—MEASUREMENT AND QUALITY ASSURANCE, NBS, Gaithersburg, MD; sponsored by NBS, American Medical Association, and ASTM; contact: Howard T. Yolken, A261 Metrology Building, NBS, 301/921?3786.

### October 7-9

36TH CALORIMETRY CONFERENCE, NBS, Gaithersburg, MD; sponsored by NBS and University of Colorado; contact: Robert Goldberg, A303 Physics Building, NBS, 301/921-2752.

### October 13-15

6TH ANNUAL CONFERENCE ON MATERIALS FOR COAL CONVERSION AND UTILIZATION, NBS, Gaithersburg, MD; sponsored by NBS, DOE, EPRI, and GRI; contact: Samuel Schneider, B308 Materials Building, NBS, 301/921-2894.

### October 21-23

MECHANICAL FAILURES PREVENTION GROUP, NBS, Gaithersburg, MD; sponsored by NBS and MFPG; contact: T. Robert Shives, B120 Materials Building, NBS, 301/921-2934.

### November 23-24

DEFORMATION, FRACTURE, WEAR, AND NONDESTRUCTIVE EVALUATION OF MATERIALS: PHYSICS AND PRACTICE, New Orleans, LA; sponsored by NBS and APS; contact: Robb Thomson, A311 Materials Building, NBS, 301/921-2103.

# PUBLICATIONS

## NBS RESEARCHER SEEKS REALISTIC BASIS FOR LIGHTING LEVELS

*Yonemura, G. T., Criteria for Recommending Lighting Levels, Nat. Bur. Stand. (U.S.), NBSIR 81-2231, 57 pages (Mar. 1981). Order by Stock No. PB 81-185126 from National Technical Information Service, Springfield, VA 22161; for $8 prepaid.**

"I can just see the gray spot. . . ."

"I see that it is oval-shaped. . . ."

"I think the number is a 3 and not an 8. . . ."

"I can barely make out the letter E under this light but it is quite legible under that light. . . ."

How valid are these and other typical responses obtained experimentally by researchers concerned with workplace lighting and its effectiveness?

Lighting levels, and how they affect the vision of workers performing everyday office tasks, are considered in *Criteria for Recommending Lighting Levels,* a new publication of the National Bureau of Standards.

Published as one of a series of Department of Energy-sponsored NBS reports involving energy and cost data research, the study documents a need for improved experimental procedures as a practical basis for establishing illumination levels conforming to "real-world office activities."

Reviewing varying approaches to the problem, the report's author, Gary T. Yonemura, concludes that "for consistency and general applicability, physiological and psychophysical laboratory studies . . . (of) how well the eye 'sees' are the most appropriate and defensible basis for determining lighting level standards and guidelines."

Yonemura, a psychophysicist in the NBS Center for Building Technology, in discussing the advantages and disadvantages of the traditional "threshold" definition of visibility, observes: "Since most real-world tasks are being performed at visibility levels significantly higher than the 'just detectable,' 'recognizable,' and 'identifiable' levels, we should investigate the function of the eye at levels beyond this minimum or threshold level. . . ."

Citing cases from the literature where prediction of performance from threshold data led to erroneous conclusions, Yonemura in his report maps research needs in the suprathreshold area—the most relevant to visibility requirements in typical office and commercial work situations. Defining conspicuity or ease of seeing as "how well the detail stands out from the background," he notes that some of the early findings in suprathreshold visibility research have been unexpected.

The popular assumption that "more light leads to better sight," for example, is not always true. Yonemura reports that for workers dealing with high-contrast patterns there is an optimum level, so that the required eye sensitivity to contrast may actually decrease if illumination is higher than the optimum level. "Setting light levels higher than necessary for an infrequently encountered difficult task," he observes, "is therefore not only wasteful of energy, but can lead to temporary visibility losses for other more frequently encountered tasks."

Since the need, according to Yonemura, is for a measure "covering the gamut of visual sensitivity" as a basis for applicable standards, he warns against research that blurs necessary distinctions between physiological measurement of visual response and data based on subjective, individual-preference responses. While subjective data may be useful in selecting some lighting design options relating to mood and comfort, the primary target, Yonemura emphasizes, should be "standardized light levels required to see." Concentrating on that target, his study identifies the major categories of variables included in the perception of the visual environment and organizes them logically with respect to their relationship in developing lighting criteria and standards.

## SOLAR COLLECTORS DESIGNED FOR ALL SEASONS

*Cattaneo, L., Harris, J. R., Reinhold, T. A., Simiu, E., and Yancey, C. W. C., Wind, Earthquake, Snow, and Hail Loads on Solar Collectors, Nat. Bur. Stand. (U.S.), NBSIR 81-2199, 97 pages (Jan. 1981). Order by Stock No. PB 81-164550 from National Technical Information Service, Springfield, VA 22161; for $9.50 prepaid.*

Flat-plate solar collectors are becoming increasingly common as a feature of new buildings or a retrofitted improvement for older ones. Catching and harnessing the sun's rays efficiently is not the only requirement; depending on locale, a solar collector may have to shed snow, stand up to winds, absorb earth tremors, or survive hailstorms to do its job reliably and safely.

*Wind, Earthquake, Snow, and Hail Loads on Solar Collectors,* a four-part report by the National Bureau of Standards, has now been published as a source document primarily for use by code- and standard-writing bodies in developing minimum design loads for solar collectors. Prepared for the Department of Energy by an NBS Center for Building Technology team, the report presents guidelines and criteria based on recent experimental data and on the current draft revision of Standard A58.1 ("Building Code Requirements for Minimum Design Loads in Buildings and Other Structures") of the American National Standards Institute (ANSI).

The NBS report reflects results from:

- 1500 wind-tunnel tests of models representing some 63 different solar collector configurations
- comparisons of wind-tunnel and full-scale field tests for wind loads

---

** Publications cited here may be purchased at the listed price from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402 (foreign: add 25 percent). Microfiche copies are available from the National Technical Information Service, Springfield, VA 22161. For complete periodic listings of all scientific papers and articles produced by NBS staff, write: Editor, Publications Newsletter, Administration Building, National Bureau of Standards, Washington, DC 20234.*

- an analysis of the relative importance of seismic forces in the design of solar collector systems
- findings from studies of snow accumulation around solar collectors during the winter of 1978-79
- recent hail damage risk studies coupled with a comprehensive hail climatology review.

Consideration is given to typical configurations of solar collectors, including roof- and wall- as well as ground-supported solar collectors. Roof-supported systems included single or multiple rows of protruding collectors and collectors mounted flush with sloping roofs.

Part I of the report sets forth equations for use in determining design wind pressures for solar collector cover plates, individual collector units, and arrays of collectors, considering both safety and serviceability requirements. These equations and procedures are presented to allow designers to extend the provisions of the draft revision of ANSI A58.1 to the design of solar collector systems and supporting buildings. Also discussed is the safety of buildings and foundations supporting collector systems. With respect to solar collectors forming the roof surface of buildings, the researchers found previously developed roof wind load criteria to be applicable.

Part II, dealing with earthquake loads on solar collectors, concludes that the anchoring systems and relatively light weight of "rigid" and "rigid-supported" solar collector panel assemblies would enable them to resist the seismic forces specified for parts and portions of structures under Standard A58.1's current draft revision. Documentation on earthquake loads is provided.

Findings from studies of snow accumulation around solar collectors in 1978-79 are given in Part III, along with proposed specific design criteria. The criteria address the functioning and serviceability of solar collectors and buildings as well as resistance to structural failure.

A proposed procedure for determining design hail loads, presented in Part IV, reflects recent information not available when the earlier ANSI standard was developed. The new data, according to the authors, represent an improvement, but they cite a need for additional research to reduce remaining uncertainties in the field of hail loading statistics. Part IV includes information on regionalization of the United States, maximum hailstone sizes, hailstone velocities, and hailstone density.

## SEISMIC STANDARD DRAFTED FOR FEDERAL BUILDINGS

*Harris, J. R., and Leyendecker, E. V., Draft Seismic Standard for Federal Buildings, Nat. Bur. Stand. (U.S.), NBSIR 81-2195, 95 pages (Jan. 1981). Order by Stock No. PB 81-163842 from National Technical Information Service, Springfield, VA 22161; for $9.50 prepaid.*

As part of its continuing cooperation in the National Earthquake Hazards Reduction Program, the National Bureau of Standards has published a *Draft Seismic Standard for Federal Buildings* (NBSIR 81-2195)

Prepared for uniform use by all Federal agencies as an adaptation of existing voluntary standards, model building codes, Federal regulations, and research reports, the draft standard was developed by members of the building standards subcommittee of the Federal Interagency Committee on Seismic Safety in Construction (ICSSC).

The draft standard is most closely related to the Uniform Building Code as published by the International Conference of Building Officials (ICBO) and the *Recommended Lateral Force Requirements and Commentary* on which the ICBO model code was based. However, there are some substantial differences: several important provisions in the draft standard, including the seismic zoning map, have been adapted from *Tentative Provisions for the Development of Seismic Regulations for Buildings*, developed by the Applied Technology Council and published by NBS. Other provisions in the draft standard reflect current practices and policies of various Federal agencies. Preparation of the standard was sponsored by the Federal Emergency Management Agency and NBS.

Federal agencies concerned with construction of buildings are being asked to test the standard through use in design, contract administration, and quality control, either on a trial or real basis during 1981. Trial implementation and comments on the draft will be followed by subcommittee review, with revision as necessary, before the document is submitted for adoption by the Interagency Committee as a practice recommended for Federal buildings.

## PUBLICATIONS LISTING

### Building Technology

Rossiter, W. J., Jr., Mathey, R. G., Busching, H. W., and Cullen, W. C., Cooling of Bitumen During Construction of Built-Up Roofing Systems—A Mathematical Model, Nat Bur. Stand. (U.S.), Tech. Note 1135, 76 pages (Mar. 1981) Stock No. 003-003-02302-7, $4 prepaid.

Yokel, F. Y., Yancey, C. W. C., and Mullen, C. L., A Study of Reaction Forces on Mobile Home Foundations Caused by Wind and Flood Loads, Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 132, 84 pages (Mar. 1981) Stock No. 003-003-02301-9, $4 prepaid.

### Electronic Technology

Mitchell, M. A., and Linholm, L. W., Semiconductor Measurement Technology: Test Patterns NBS-28 and NBS 28-A: Random Fault Interconnect Step Coverage and Other Structures, Nat. Bur. Stand. (U.S.), Spec. Publ. 400-65, 35 pages (Mar. 1981) Stock No. 003-003-02297-7, $2 prepaid.

### Environmental Studies: Pollution Measurement

Noyce, J. R., Evaluation of Methods for the Assay of Radium-228 in Water, Nat. Bur. Stand. (U.S.), Tech. Note 1137, 18 pages (Feb. 1981) Stock No. 003-003-02294-2, $1.50 prepaid.

### Instrumentation and Experimental Methods

Siegwarth, J. D., and LaBrecque, J. F., A Portable Calibration Densimeter for Use in Cryogenic Liquids, Nat. Bur. Stand. (U.S.), Tech. Note 1035, 20 pages (Mar. 1981) Stock No. 003-003-02308-6, $1.50 prepaid.

# NEWS BRIEFS

INEXPENSIVE, STABLE LASER DEVELOPED. Physicists at the Joint Institute for Laboratory Astrophysics (JILA) have developed a low-cost helium-neon laser that is stable to a part in $10^{-9}$. It will be useful to physicists, astronomers, chemists, and others as a reliable reference source for wavelength measurements. It utilizes commercially available laser tubes and can be built for less than $1,000. A workshop on how to construct a stabilized Zeeman laser is planned for the fall. For information, contact J. L. Hall, JILA, University of Colorado and National Bureau of Standards, Boulder, CO 80303.

SOLID FUELS PROPERTIES PROGRAM. A solid fuels properties research program has been initiated by NBS' Center for Chemical Engineering. In response to the need for expanded thermophysical properties data for solid fuels, NBS is validating the precision and accuracy of new measurement equipment, assessing conventional measurement procedures, and interpreting the results. Ultimately, the program will emphasize the development of accurate, data-predictive techniques applicable to solid fuels, such as coal and oil shale, and complex heterogeneous solids like natural gas hydrates. To a large extent, the work will be collaborative with industry, professional organizations, academia, and other laboratories.

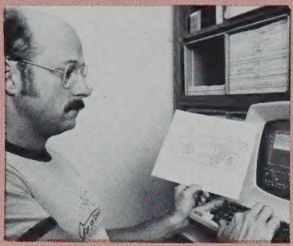
STANDARD BEING DEVELOPED FOR RADIO FREQUENCY TESTING. NBS scientists are developing a standard radiating device that Government and industry can use to calibrate the accuracy of various radio frequency test facilities. The small, spherical dipole radiator is self-contained and could be used as a transfer standard. It has been tested successfully at 30 MHz and resonant frequencies up to 240 MHz. NBS expects eventually to provide a frequency range from 10 MHz up to GHz. A paper describing the device is available.

NBS PRECISION MEASUREMENT GRANTS. NBS is seeking proposals for up to four $30,000 grants in 1983 for research in the fields of precision measurement of physical quantities or the determination of fundamental constants. These grants are generally awarded to academic researchers and may be renewed for up to 2 additional years. The program is run in cooperation with the National Science Foundation. Preliminary proposals must be submitted by February 1, 1982. For details, contact Dr. Barry Taylor, B258 Metrology Building, National Bureau of Standards, Washington, DC 20234, or call 301/921-2701.

NCSL DIRECTORY NOW AVAILABLE. The 1981-1982 National Conference of Standards Laboratories (NCSL) *Directory of Standards Laboratories* is now available at no charge. It lists approximately 800 standards laboratories with name, address, personal contact, and telephone number. It is indexed alphabetically, by laboratory capability, zip code (location), and generic classification (e.g., Federal Government, State Government, private, Army, Navy, and NASA). The directory is published biennially by NCSL, a professional organization sponsored by NBS. Send requests to: NCSL Secretariat, 4001 Radio Building, National Bureau of Standards, 325 Broadway, Boulder, CO 80303.

## NEXT MONTH IN

# DIMENSIONS NBS



*Knowing how fires, and the smoke and gases they produce, spread from room to room could help save lives and property. In the next issue of DIMENSIONS/NBS, read how fire researchers at NBS are developing mathematical models to help further our understanding of fire as a physical and chemical phenomenon.*

**U.S. DEPARTMENT OF COMMERCE**
**Malcolm Baldrige, Secretary**

NATIONAL BUREAU OF STANDARDS
Ernest Ambler, Director

Prepared by the Public Information Division
Washington, DC 20234

Richard S. Franzen, Chief

Sharon Shaffer, Chief
General Publications

Jan Kosko, Acting Editor

Justine A. Williams, Assistant Editor

Stan Lichtenstein, Production

Walt Mortensen, Visual Editor
(Commerce Department)

PHOTO CREDITS

*Beamie Young, pages 2, 5, 7-9, 13, and 14.*

The Commerce Department's National Bureau of Standards was established by Congress in 1901 to advance the Nation's science and technology and to promote their application for public benefit. NBS research projects and technical services are carried out by the National Measurement Laboratory, the National Engineering Laboratory, and the Institute for Computer Sciences and Technology. Manufacturing, commerce, science, government, and education are principal beneficiaries of NBS work in the fields of scientific research, test method developments, and standards writing. DIMENSIONS/NBS describes the work of NBS and related issues and activities in areas of national concern such as energy conservation, fire safety, computer applications, materials utilization, and consumer product safety and performance. The views expressed by authors do not necessarily reflect policy of the National Bureau of Standards or the Department of Commerce.

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Annual subscription: Domestic, $11.00, foreign, $13.75. Single copy: Domestic, $1.10, foreign, $1.40. The Secretary of Commerce has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through June 30, 1982.

AN EQUAL OPPORTUNITY EMPLOYER

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
Washington, DC 20234

OFFICIAL BUSINESS
Penalty for Private Use, $300
RETURN POSTAGE GUARANTEED

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF COMMERCE
COM-215

U.S.MAIL

CONTROLLED CIRCULATION RATE